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Case Report

In Situ Bypass from the Brachial to Radial Artery in the Anatomical Snuffbox for Limb Salvage in End-Stage Renal Disease

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Diabetes and renal failure frequently involved in small vessel arteriopathy. With medical advancements, those patients survive longer with an increasing incidence of resultant arterial occlusive disease affecting the distal upper extremity (UE). In patients with ulcers or gangrene in the distal UE, bypass surgery is often complicated by severe atherosclerosis with calcification, resulting in poor distal anastomosis quality. Here we report a patient with a fingertip gangrene who were successfully treated with in situ bypass from the brachial artery below the elbow to the radial artery in the anatomical snuffbox under local anesthesia. Bypass graft patency was maintained during the 18-month follow-up. If the forearm cephalic vein and radial artery in the anatomical snuffbox are of adequate quality, in situ bypass to radial artery in the anatomical snuffbox may be a useful option for limb salvage in selected patients.

Key Words: Vascular grafting, Ischemia, Upper extremity, Renal insufficiency

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INTRODUCTION

Symptomatic atherosclerotic disease affecting the upper extremity (UE) is rarer than that affecting the lower extremity (LE) [1]. UE arterial disease due to atherosclerosis generally affects the large vessels, including the brachiocephalic trunk, subclavian, and axillary arteries. Distal lesions are mainly related to nonatherosclerotic diseases, including autoimmune or connective tissue disorders, embolism, Buerger disease, and secondary Raynaud phenomenon [2]. However, with the advancement of medical management regarding the central causes of atherosclerosis affecting the smaller arteries, such as diabetes and renal failure, patients with such systemic vascular diseases survive longer with an increasing incidence of resultant arterial occlusive disease affecting the distal UE.

Digital ischemia in the UE is problematic and usually observed in patients with arteriovenous fistula undergoing hemodialysis. Digital ischemia in patients with preexisting atherosclerosis often worsens due to "stealing" of the arterial flow from the hand. Therefore, many reports have detailed the operative methods developed to manage this condition. However, direct reconstruction for UE arterial occlusive disease without an arteriovenous fistula is rare, accounting for less than 4% of all bypass procedures; therefore, few data are available for evaluating outcomes [1,3]. Here we describe our treatment and surgical consideration of a patient who presented with fingertip gangrene and underwent in situ bypass from the brachial artery to the radial artery in the anatomical snuffbox. The case report was approved by Institutional Review Board of Kyungpook National University Hospital (IRB no. 2021-07-064).

CASE

A 67-year-old female complained of a 2-week history of left 3rd finger pain and purplish discoloration (Fig. 1A). Her medical history was significant, with hypertension, diabetes mellitus, coronary artery disease, and atrial fibrillation. Seventeen years prior, she had started hemodialysis due to chronic renal failure related to adult-onset diabetes mellitus and had undergone living-donor renal transplantation after dialysis with a central venous catheter for 6 months. Additionally, her medication use was significant, including immunosuppressants, aspirin, warfarin, statins, and insulin. On physical examination, the brachial artery pulse was easily palpable; however, the radial artery pulse was absent, and she complained of tenderness of the left 3rd fingertip upon touching.

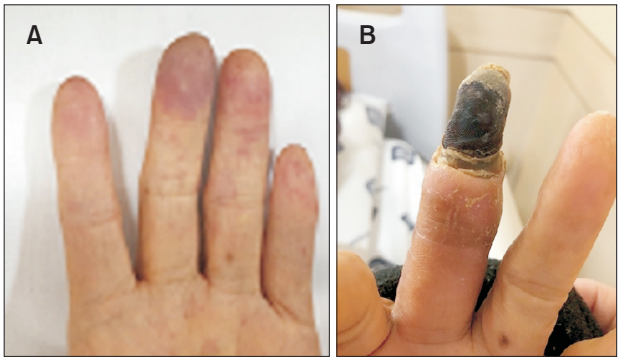

Fig. 1. Clinical photographs at the time of the initial diagnosis and follow-up. (A) The patient initially complained of a 2-week history of left 3rd finger pain and purplish discoloration. (B) Two months later, she revisited the outpatient clinic with worsening pain and necrosis of the 3rd fingertip accompanied by infection.

The wrist-brachial index demonstrated noncompressible forearm arteries and a decreased value in the left arm, and the waveforms of the wrist arteries were monophasic in both arms. Photoplethysmography revealed a flat waveform in the left fingers. Duplex ultrasonography (DUS) showed patent axillary, brachial, proximal radial, and ulnar arteries; however, the mid to distal radial and ulnar arteries showed heavy calcification with total occlusion. Considering the clinical manifestation of gradually aggravating pain and DUS findings of chronic atherosclerotic change with severe calcification in both UE arteries, thromboembolism could be excluded. Moreover, she was taking a therapeutic dose of warfarin for atrial fibrillation. Because she complained of limb-threatening ischemia, we recommended a further evaluation and revascularization for symptom relief; however, she chose conservative management and refused to undergo surgery at that time.

Two months later, the patient revisited the outpatient clinic with worsening pain and necrosis of the 3rd fingertip, and the wound showed signs of infection (Fig. 1B). Repeated DUS demonstrated similar findings as before. The distal radial and ulnar arteries at the wrist were inadequate for bypass due to heavy calcification and occlusion; however, the radial artery in the anatomical snuffbox was considered adequate for bypass since it lacked severe calcification and had collateral branches. The diameter of the radial artery on the snuffbox was about 1.7 mm in outer diameter and 1.1 mm in inner diameter. The diameter of the forearm cephalic

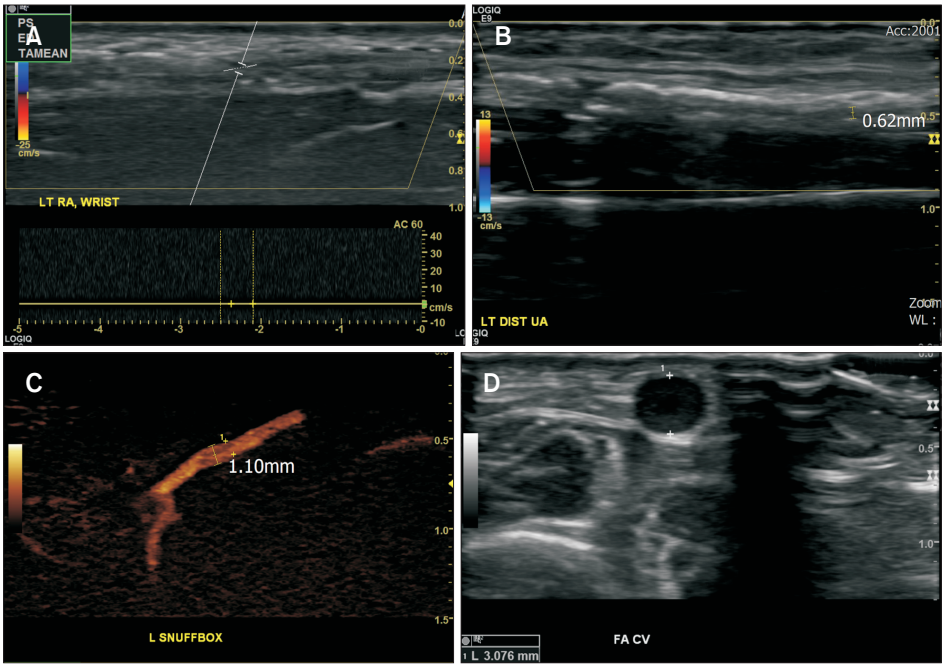

Fig. 2. Preoperative duplex ultrasonography evaluation of the left forearm vessels. (A) At the wrist level, the radial artery was completely occluded. (B) The distal ulnar artery was occluded with severe calcification. (C) The radial artery in the anatomical snuffbox showed mild intraluminal stenosis due to atherosclerosis. However, the calcification was not severe and distal branch patency was observed. The artery was 1.7 mm in outer diameter and 1.1 mm in inner diameter. (D) The diameter of the forearm cephalic vein was approximately 2 to 3 mm.

vein was 2.0 to 3.0 mm, with compressibility on DUS (Fig. 2). Therefore, we decided to perform bypass surgery from the brachial artery below the elbow to the radial artery in the anatomical snuffbox, and an in situ bypass was planned because the quality of the forearm cephalic vein was considered adequate.

The operation was performed under local anesthesia. First, the cephalic vein at the anatomical snuffbox was gently dissected, small brachial artery below the elbow to the radialartery in the snuffbox was dissected. Second, the cephalic vein at the cubital fossa was dissected, and the brachial artery just distal to the elbow skin crease was exposed to enable proximal anastomosis. After division of the cephalic vein at the cubital fossa, a proximal anastomosis was performed in a side-to-end fashion. The cephalic vein at the snuffbox was divided, and a Mills retrograde valvulotome was gently inserted toward the proximal anastomosis. After three sessions of valve lysis with the valvulotome, pulsatile flow was achieved at the distal end of the cephalic vein. Next, a distal anastomosis was performed at the radial artery in the anatomical snuffbox using 7-0 Surgipro polypropylene sutures (Covidien, Mansfield, MA, USA). Thereafter, DUS was applied intraoperatively, and three branches of the cephalic vein were ligated with small incisions (Fig. 3). Only remarkable branches with a substantial amount of blood flow were ligated, and other small branches were left untouched. On follow-up DUS, distal flow was not hampered by the untied small branches.

The patient's postoperative course was uneventful, and she underwent amputation of the 3rd fingertip 2 weeks after bypass surgery. The wound healed well after the fingertip amputation, and she has been doing well during the 18-month follow-up period with patent bypass graft on follow-up DUS (Fig. 4, 5).

DISCUSSION

UE arterial disease can be caused by various pathologies

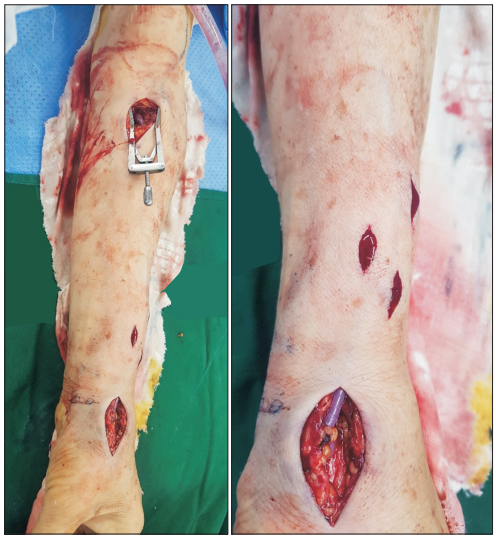

Fig. 3. Operative images after completing both anastomoses and branch ligation. After distal anastomosis, duplex ultrasonography was applied, and 3 branches of the cephalic vein were ligated with small incisions.

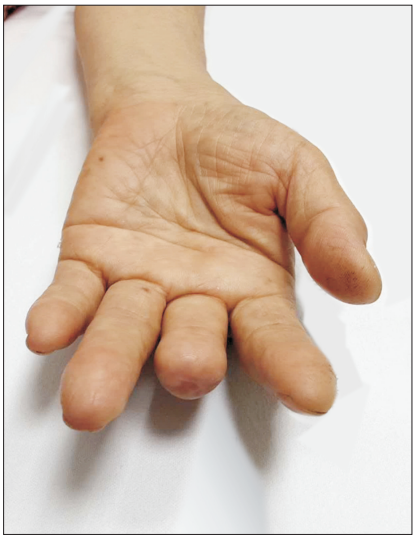

Fig. 5. Clinical photograph was taken at 18 months postoperative. The amputated 3rd finger was completely healed.

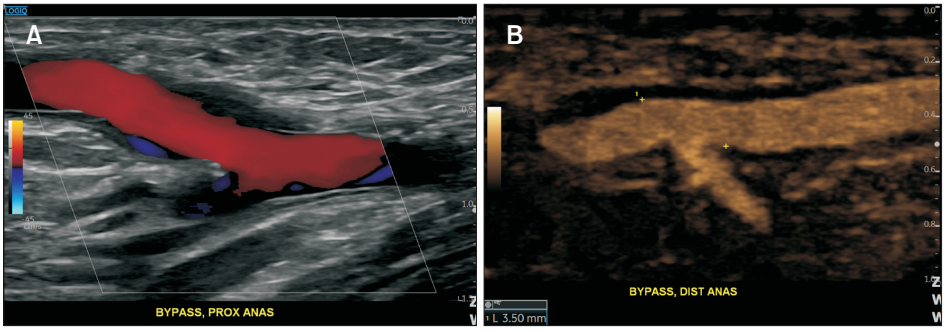

Fig. 4. Duplex ultrasonography was performed 12 months after the operation. The patency of the entire graft from the proximal anastomosis (A) to the distal anastomosis (B) was maintained well without stenosis or occlusion.

and is categorized into small and large vessel arteriopathy by the anatomical location of the involved arterial territory. Small vessel arteriopathy involving arteries distal to the wrist mainly occurs in autoimmune or connective tissue disorders such as scleroderma, rheumatoid arthritis, and systemic lupus erythematosus. In contrast, atherosclerosis is the most common cause of large vessel arteriopathy in the UE. In UE, small vessel arteriopathy affecting the palmar and digital arteries is more common than large vessel arteriopathy, which accounts for less than 10% of UE arterial occlusive disease [4]. The majority of large vessel arteriopathy in the UE are associated with atherosclerosis in the brachiocephalic and subclavian arteries, in patients with classic risk factors for atherosclerosis [2]. Other causes of large vessel arteriopathy include thoracic outlet syndrome, embolism, and some autoimmune arteriopathies, such as Takayasu arteritis [2]. However, the incidence of atherosclerosis affecting the smaller arteries, such as in diabetes and renal failure, has been increasing in line with global changes, as patients with such systemic vascular diseases survive longer and the incidence of resultant arterial occlusive disease of the distal UE is increasing. Although our patient had atrial fibrillation, atherosclerosis of the below-the-elbow arteries was the suspected cause of digital ischemia because of the long history of diabetes and renal failure and classic DUS findings without any embolic materials.

Unlike the LE, the UE is less likely to be affected by chronic limb-threatening ischemia (CLTI), including tissue loss, possibly due to its abundant collateral circulation. In a previous report of acute UE arterial occlusive disease, the limb loss rate was less than 10% in acute axillary artery occlusion, while the rate of digital gangrene was reportedly less than 5% in acute occlusion of the brachial artery distal to the deep artery branch [4]. In addition, Mills et al. [5] reported a series of 100 patients with ischemic finger ulceration and demonstrated that the etiology was an autoimmune disease in 54%, hypersensitivity angiitis in 22%, Buerger disease in 9%, arteriosclerosis obliterans in 9%, and miscellaneous diseases in 6%. Therefore, CLTI in UE associated with atherosclerosis seems relatively rare and related to a lower rate of tissue loss than that in LE. However, mirroring the problems in the LE, below-the-elbow disease might be an important cause of tissue loss in patients with diabetes and renal failure for which limb salvage requires revascularization.

The treatment options for patients with UE and CLTI consist of conservative treatment with local wound care and medications, endovascular treatment, and surgical bypass. Conservative therapy can be applied to patients with significant comorbidities or minimal symptoms. Cheun et al. [6] reported the results of conservative therapy in 53 (49%) patients among the 108 patients with symptomatic below-the-elbow atherosclerotic disease. The 3-month symptom relief rate was 31%, and the wound healing rate was 69%. Interestingly, no major amputation was performed in 30 days, which might be related to the abundant collateral circulation in the UE. However, conservative therapy in patients with no revascularization options resulted in lower wound healing and symptom relief rates than endovascular and bypass interventions [6]. Endovascular treatment for UE arterial occlusive disease is not popular because of the relative infrequency of interventions or the underlying causes of arterial disease. In particular, there have been many reports on the utility of the endovascular approach for above-the-elbow UE arterial disease, including subclavian artery occlusive disease, but there are very limited data on the outcomes of endovascular treatment for below-the-elbow atherosclerotic disease. Meanwhile, surgical treatments that are suggested in the current guidelines are confined to above-the-elbow arterial disease and include various options for reimplantation, anatomical and extra-anatomical bypass with a prosthetic graft, and a transthoracic approach. Regarding distal UE arterial disease, only a few small-scale studies have detailed bypass with autologous veins such as the great saphenous vein, arm vein, small saphenous vein, or rarely with an artificial graft; however, excellent 1- and 3-year patency rates of ≥85% and ≥75% have been reported [7,8]. Therefore, if revascularization is necessary for patients with CLTI due to atherosclerotic below-the-elbow occlusive disease and distal collateral branches are preserved, surgical bypass is currently the mainstay for revascularization.

In bypass procedures for below-the-elbow UE arterial occlusive disease, choosing the distal bypass site is important and often complicated by densely calcified distal radial and ulnar arteries in patients with longstanding diabetes and renal failure. In this situation, the radial artery in the anatomical snuffbox is often patent and soft enough to allow passage of the needle. Therefore, a complete DUS examination or arteriography is essential for evaluating below-the-elbow atherosclerotic disease requiring revascularization and planning bypass surgery. In our case, we did not use conventional angiography because the dorsal carpal branch of the radial artery and palmar arch was patent on DUS examination and the patient showed insufficient renal function to allow CT angiography; however, conventional angiography may be the gold standard for the detailed evaluation of the arterial anatomy of the hand in complex and suspicious cases. We performed this operation under local anesthesia with an in situ configuration. There are some benefits of in situ bypass for peripheral arterial occlusive disease. First, the size match is better than

that in a reversed fashion. Second, this procedure can be performed with minimal incisions and dissection under local anesthesia, so it can be applied in fragile patients with multiple comorbidities because of reduced surgical stress. The results of bypass for below-the-elbow atherosclerotic occlusive disease are generally satisfactory. Chang et al. [9] performed UE brachial artery to distal artery bypass grafting at the level of the wrist or proximal hand for limb salvage in 18 limbs of 15 patients with end-stage renal failure. All bypasses were performed using vein grafts (8 limbs with arm veins, and 10 limbs with great saphenous veins), and the results demonstrated occlusion in two bypass grafts (11%) in the early postoperative period, resulting in the progression of gangrene. In the remaining 16 grafts, patency was maintained (mean follow-up, 18 months) with pain control and tissue healing. Although uncommon, the successful utilization of in situ or composite in situ arm vein bypass in UE CLTI caused by atherosclerotic disease has been reported [10,11].

In summary, in situ bypass from the brachial to radial artery in the anatomical snuffbox may be a valuable limb salvage option in patients with symptomatic forearm arterial occlusive disease if the cephalic vein and radial artery quality in the anatomical snuffbox are adequate for bypass surgery.

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CONFLICTS OF INTEREST

The authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

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